Test Lab Work Request Form

Rev.3 –20 April, 2000

Date Submitted: 09-17-01	**Tracking # : TLW 0681**
Project # : 241314	**Engineer: M. Keeney**
Test Objective: Verify performance of modified Model 710 ISS Lock Plungers.	
Test Description: Subject firing pin assemblies to DAT test protocol as deemed necessary to qualify changes to the lock plunger.	
Resource Usage: **Manpower Requirements –** **Facility Requirements –**	**Test Results Required:** **Formal Report: X Data Only:** **Requested Completion Date: 10-01-01**
Required Materials/Parts/Equipment (include quantities): 10 Bolt Assemblies supplied.	
Test Parts Availability Date: 9-17-01	
Start Date: ? **Completion Date:** 11-12-01 **Report Date:** 11-12-01	**Test Assigned To:** B. Rages **Assignment Date:** ?

Model 710 ISS Dry Cycle

Brian Rages

11/12/01

PURPOSE

The purpose of this test was to evaluate the characteristics of ISS systems with a chamfered plunger before and after dry-cycling.

CONCLUSIONS

Eleven ISS units were considered. Ten were ISS units with a new chamfered plunger design and one had the original non-chamfered design.

All ISS units passed a four-point function test before testing. All the dry-cycled units passed the function check after dry-cycling.

The torque required to lock and unlock each ISS unit was measured before and after 5,000 cycles of testing. Dry-cycling generally caused a drop in torque. The chamfered ISS units required higher torques to lock and unlock than the non-chamfered ISS unit, before and after dry-cycling.

One of the chamfered-plunger ISS units was cycled an additional 5,000 cycles. After 10,000 cycles, the peak lock torque had risen 5%. The peak unlock torque had dropped an additional 16%.

Each of the 5,000-cycle ISS units was disassembled, as well as the 10,000-cycle ISS unit. Wear was visible on the parts inside, but the parts did not appear worn out.

PROCEDURE

Eleven bolts were tested. Ten of these had the newer chamfered-plunger ISS design and one had the older non-chamfered plunger. Out of the ten chamfered-plunger bolts, one was randomly selected to be the 10,000-cycle bolt and was labeled Bolt 1. Four of the other chamfered bolts were randomly selected for 5,000-cycle testing and were labeled Bolts 2-4. The other five chamfered bolts were labeled Bolt 6-10. The non-chamfered bolt was labeled Bolt 11.

Before testing, each bolt was put through a four-point testing procedure outlined in Test Lab Work Request TLW 0681. The procedure is summarized as follows:

1. *ISS Lock Effectiveness* The ISS was locked and an attempt was made to close the bolt on a primed case without using excessive force. If the bolt closed the trigger was to be pulled with the safety off. If the primer remained unfired, the ISS was to be unlocked. Primer ignition during the test resulted in failure.

2. *ISS Lock Intrusiveness* The ISS, when unlocked, must not prevent a primed case from being fired when the safety is off and the trigger pulled.

3. *ISS Lock Security* An attempt was made to unlock the ISS from its locked position without using the proper key. A thin flathead screwdriver was used. The test was passed if the ISS could not be unlocked.

4. *ISS Bolt Closed Behavior* An attempt was made to turn the ISS to the locked position with the bolt closed. The ISS failed if it could be turned completely to its locked position.

The torque required to lock and unlock the ISS was measured. To measure the lock and unlock torque, an ISS key was fitted with an arm made from a flat piece of spring steel. A strain gage was placed on the arm next to the key. This device may be seen in Figure 1.

To measure the torque, the bolt containing the ISS unit to be measured was clamped in a vise. The torque-measuring key was placed in the ISS and the key was rotated slowly to turn the ISS to the locked position. The force to turn the key was applied by hand to the end of the metal arm. This force caused the arm to flex. The flexing of the arm was measured by the strain gage, then recorded and converted to torque. After the ISS had been locked, the key was turned the opposite direction to unlock it. The locking and unlocking of the ISS were performed within a 20-second sampling period. This torque measurement was taken five times for each of the ISS units.

Figure 1. ISS torque measuring device.

The strain gage, a 120-ohm unit, was run into a Measurements Group Model 2311 Signal Conditioning Amplifier. The strain gage amplifier was set to a 3.5 V excitation with a wideband filter. The gain was adjusted to 575 to give a 1mV/microstrain calibration.

A Techtronix oscilloscope was used to collect the data for download into a laptop PC. The strain gage reading was multiplied by 0.7705 to convert microstrain to inch-pounds of torque.

No lubrication was added to any of the ISS cylinders, and no cleaning was performed on them. Each ISS in Bolt 1 through 5 and Bolt 11 was cycled through its 180° travel 5,000 times using a pneumatic rotary indexer. Figure 2 shows the dry-cycle fixture used. The torque on Bolt 1 was then measured and 5,000 additional cycles were placed on it.

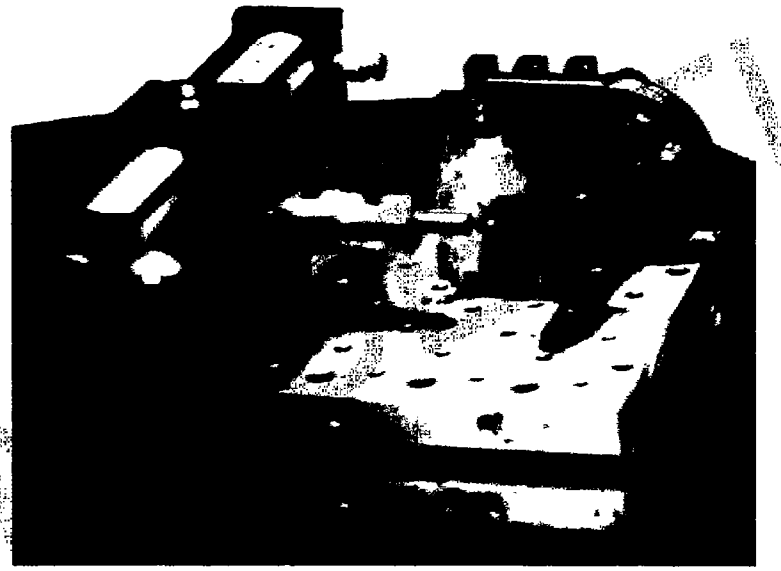


Figure 2. ISS dry cycle fixture.

After dry-cycling, the torque required to lock and unlock the ISS unit in each cycled bolt was again measured. Each cycled bolt was tested according to the four-point function test described above.

RESULTS

None of the bolts failed the function test as listed in the "procedure" section of this test before or after cycling. In each case, the bolt could not be closed with the ISS locked using a reasonable amount of force.

The torque required to lock and unlock the ISS was measured using a strain gage mounted on a flexible steel arm turning an ISS key. The strain gage reading was multiplied by 0.7705 to convert it to torque in inch-pounds. The conversion method for

converting strain gage reading to torque was given in an earlier report on ISS system dry-cycling: Model 710 ISS Dry Cycle, Brian Rages, 10/24/00.

The peak locking torques of the ISS units prior to any cycling ranged from 1.62 to 0.96 inch-pounds. The ISS unit with the nonchamfered plunger took the least torque to lock, by 0.06 pounds.

Unlocking torques for the ISS units prior to cycling varied from 0.76 to 1.35 inch-pounds, with the lightest torque required for the ISS with the nonchamfered plunger. Figure 3 contains locking and unlocking torques prior to cycling. Bolt 6 may be seen to have the highest locking and unlocking torques.

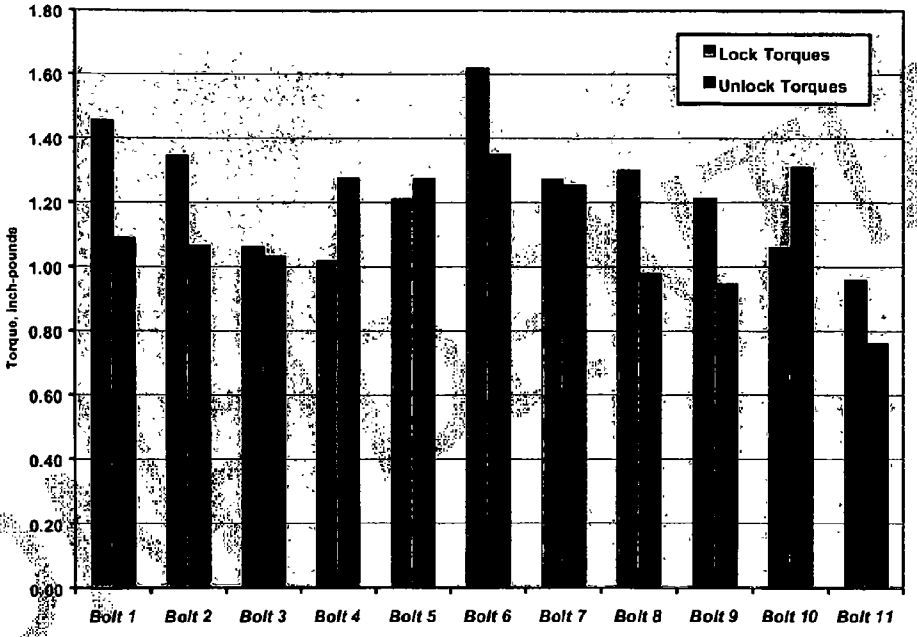


Figure 3. Torques prior to cycling.

After 5,000 cycles had been placed on bolts 1-5 and bolt 11, torques were measured again. Average locking torques on the chamfered ISS units dropped 63%, from 1.26 to 0.77 inch-pounds. Average unlocking torques on the non-chamfered units dropped 16%, from 1.16 inch-pounds to 1.00, although the unlocking torques on Bolt 2 and Bolt 3 were higher after 5,000 cycles than before the test. On Bolt 11, the bolt with the chamfered plunger, locking torque dropped 20%, from 0.96 to 0.77, and unlocking torque dropped 29%, from 0.76 to 0.54 inch pounds. Figure 4 illustrates the change in locking torque after dry-cycling, while Figure 5 shows the change in unlocking torque.

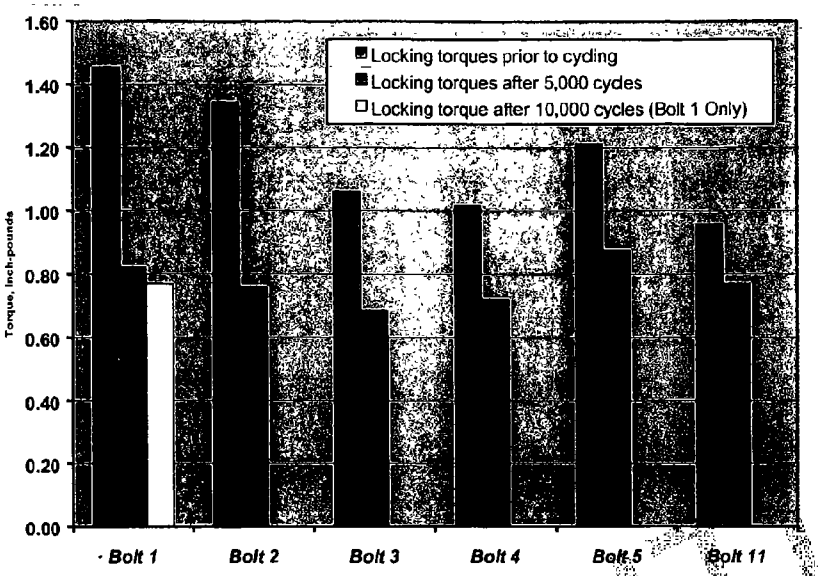


Figure 4. Locking torque change after cycling.

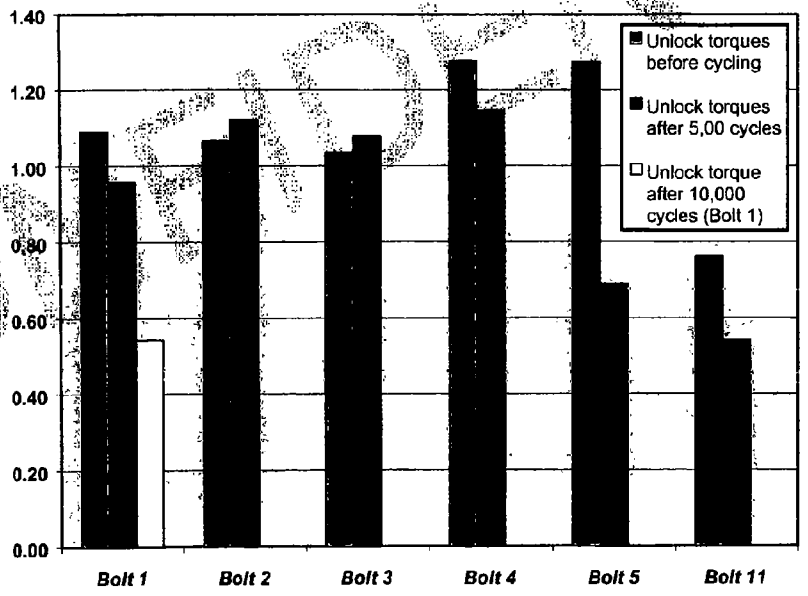


Figure 5. Unlocking torque change after cycling.

Bolt 1 was cycled an additional 5,000 times and the torque necessary to lock and unlock its ISS was measured again. Locking torque had dropped another 3.5%, to 0.77 inch-pounds, and unlocking torque had dropped another 38%, to 0.54 inch-pounds. Figures 4 and 5 contain the torques for bolt 1 after 10,000 cycles.

After the ISS systems had been cycled, the 4-point function test was repeated on the cycled bolts. All bolts passed just as they had done prior to being cycled – when engaged, the ISS device would not allow closure of the bolt.

On bolts 1 through 5 and Bolt 11, the bolt plugs were cut open, and the components of the ISS were removed for inspection. Figure 5 contains a picture of the plunger tips. None of the plungers show an extreme amount of wear. Plungers from Bolt 1 and Bolt 3 show slight wear on the tip. Some wear areas can also be seen on the tip of the plunger from Bolt 11.

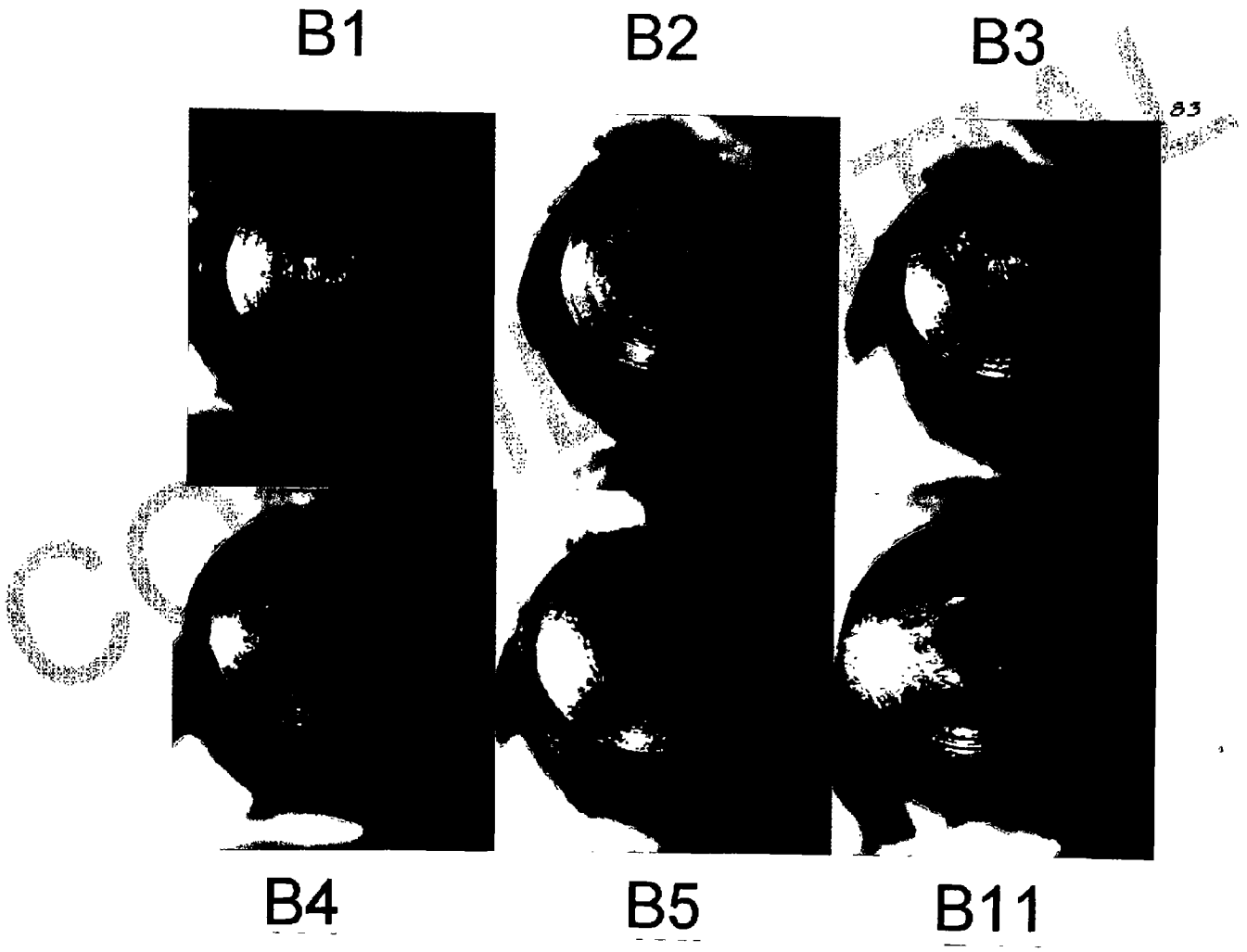


Figure 5 Plunger tips

The ISS cylinders were removed from the guns and examined. All showed fairly similar amounts of wear. Figures 6 and 7 show the plungers from Bolts 1 through 5. All have a slight band of wear across the top where the plunger rubs against the cylinder. A wear spot may be seen in Figure 7 where the plunger tip contacts its cavity.

Figure 6. ISS cylinders from Bolts 1 through 5 (left to right)

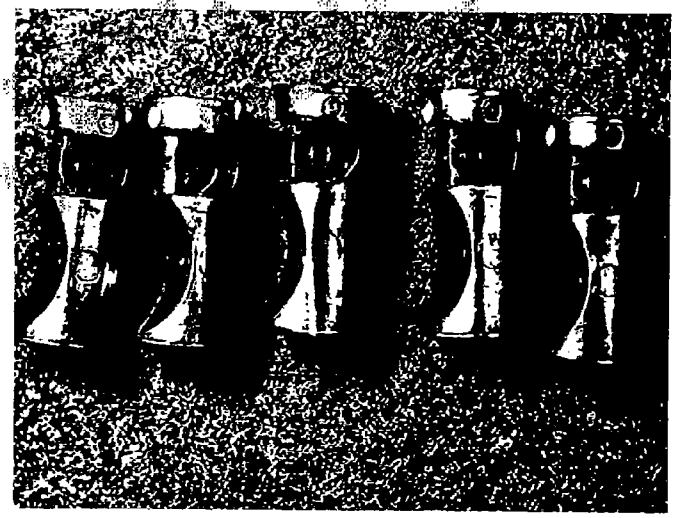


Figure 7. ISS cylinders from Bolts 1 through 5, side view (left to right)

Figure 8 and 9 contain images of the ISS cylinder from Bolt 11. It is pictured with the ISS cylinder from Bolt 1 for comparison. A similar amount of wear is visible on each cylinder.

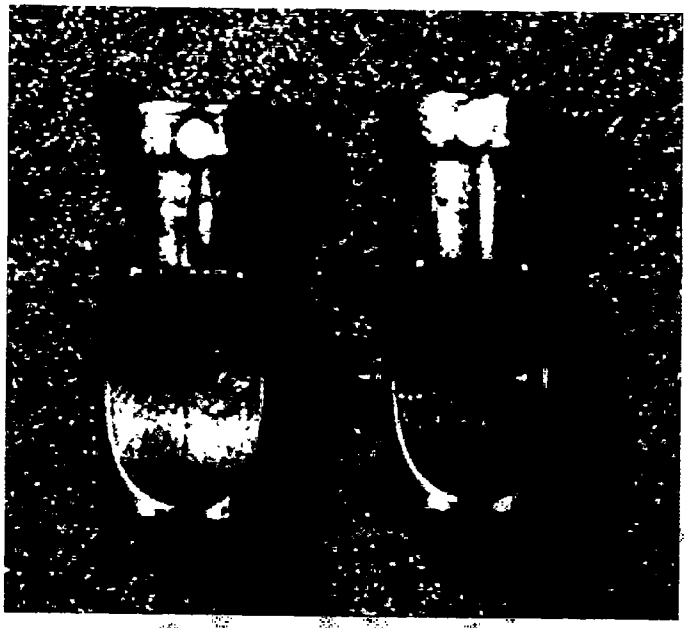


Figure 8. ISS cylinders from Bolt 1 (left) and Bolt 11 (right).

Figure 9. ISS cylinders from Bolt 1 (left) and Bolt 11 (right), side view.

DATA

Bolt Torques

Avg. cham lock:	1.26		
Avg. cham unlock:	1.16		
Avg. cham unlock after 5,000 cycles:	0.77	% drop:	62.49
Avg. cham lock after 5,000 cycles:	1.00	% drop:	16.01

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop total	% Drop of prev.
Bolt 1	Lock torque before test	1.714	1.769	1.301	1.273	1.224	1.46	0.263		
	Unlock torque before test	1.134	1.196	1.036	1.091	0.992	1.09	0.080		
	Lock torque after 5000 cycles	0.906	0.860	0.811	0.777	0.758	0.82	0.061	43.52	
	Unlock torque after 5000 cycles	0.900	0.912	1.011	0.992	0.977	0.96	0.050	12.05	
	Lock torque after 10000 cycles	0.894	0.786	0.727	0.730	0.715	0.77	0.074	47.08	3.556
	Unlock torque after 10000 cycles	0.530	0.552	0.552	0.546	0.539	0.54	0.009	50.11	38.066

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop	
Bolt 2	Lock torque before test	1.606	1.381	1.519	1.171	1.057	1.35	0.231		
	Unlock torque before test	1.066	1.110	0.974	1.060	1.125	1.07	0.059		
	Lock torque after 5000 cycles	0.912	0.777	0.697	0.740	0.678	0.76	0.093	43.52	
	Unlock torque after 5000 cycles	1.288	1.033	1.054	1.131	1.103	1.12	0.101	-5.14	

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop	
Bolt 3	Lock torque before test	1.224	1.057	1.042	1.005	0.986	1.06	0.094		
	Unlock torque before test	1.082	0.996	1.063	0.999	1.033	1.03	0.038		
	Lock torque after 5000 cycles	0.650	0.675	0.641	0.653	0.804	0.68	0.068	35.56	
	Unlock torque after 5000 cycles	1.162	1.184	1.020	1.100	0.918	1.08	0.109	-4.11	

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop	
Bolt 4	Lock torque before test	1.094	1.033	1.002	0.980	0.983	1.02	0.047		
	Unlock torque before test	1.264	1.338	1.328	1.174	1.282	1.28	0.065		
	Lock torque after 5000 cycles	0.746	0.740	0.718	0.684	0.718	0.72	0.024	29.18	
	Unlock torque after 5000 cycles	1.236	1.211	1.165	1.113	1.005	1.15	0.092	10.28	

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop	
Bolt 5	Lock torque before test	1.372	1.177	1.208	1.190	1.116	1.21	0.095		
	Unlock torque before test	1.396	1.301	1.359	1.214	1.106	1.28	0.117		
	Lock torque after 5000 cycles	1.029	0.866	0.857	0.801	0.829	0.88	0.089	27.71	
	Unlock torque after 5000 cycles	0.684	0.712	0.703	0.690	0.666	0.69	0.018	45.82	

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev		
Bolt 6	Lock torque before test	1.973	1.871	1.516	1.470	1.261	1.62	0.296		
	Unlock torque before test	1.368	1.365	1.405	1.304	1.310	1.35	0.043		

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev		
Bolt 7	Lock torque before test	1.822	1.301	1.113	1.076	1.051	1.27	0.322		
	Unlock torque before test	1.097	1.230	1.390	1.298	1.261	1.26	0.107		

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev		
Bolt 8	Lock torque before test	1.695	1.387	1.205	1.116	1.103	1.30	0.248		
	Unlock torque before test	1.023	1.017	0.937	0.992	0.928	0.98	0.045		

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev		
Bolt 9	Lock torque before test	1.455	1.097	0.986	1.575	0.955	1.21	0.283		
	Unlock torque before test	0.934	0.962	0.900	0.983	0.965	0.95	0.032		

		Measurement #								
		1	2	3	4	5	Ave	Std. Dev		
Bolt 10	Lock torque before test	1.415	1.079	0.977	0.940	0.894	1.06	0.209		
	Unlock torque before test	1.335	1.304	1.251	1.375	1.288	1.31	0.047		

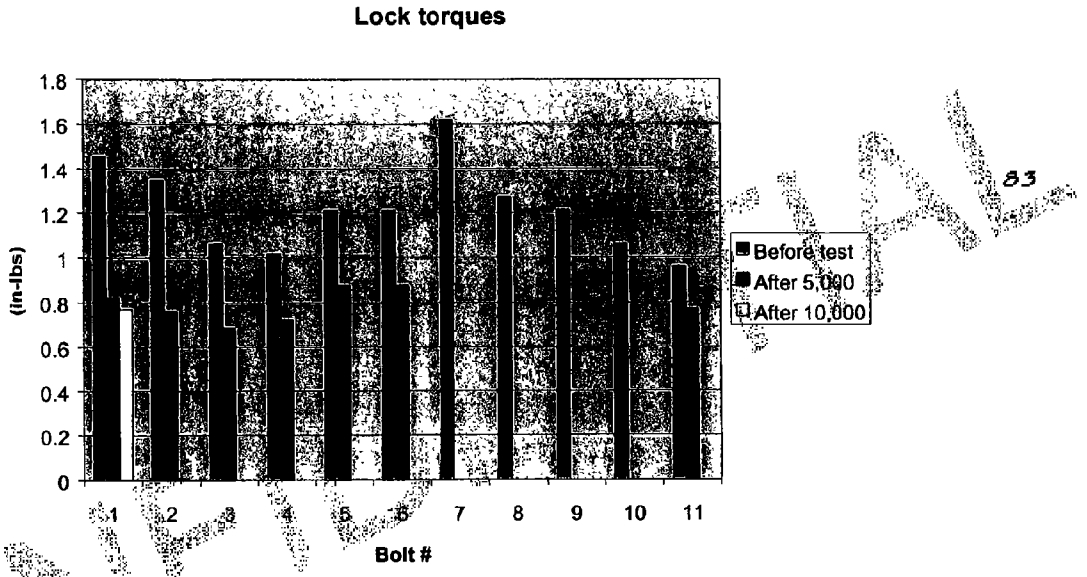
		Measurement #								
		1	2	3	4	5	Ave	Std. Dev	% Drop	
Bolt 11	Lock torque before test	0.959	0.928	0.848	0.832	0.826	0.96	0.061		
	Unlock torque before test	1.073	0.712	0.684	0.678	0.663	0.76	0.175		
	Lock torque after 5000 cycles	0.894	0.786	0.727	0.730	0.715	0.77	0.074	19.61	
	Unlock torque after 5000 cycles	0.530	0.552	0.552	0.546	0.539	0.54	0.009	28.64	

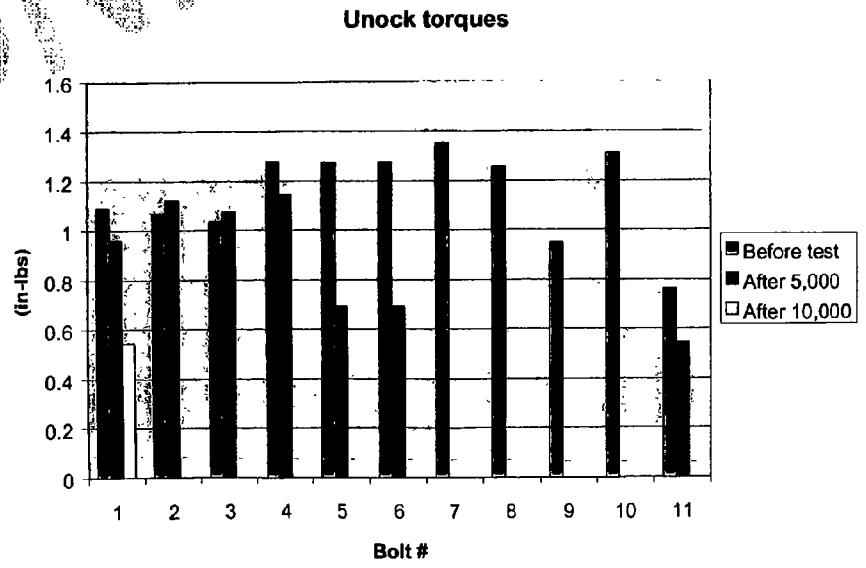
710 ISS Torques

10/15/01

Scott,

Here is data and graphs for the ISS torques before and after testing. The bolt that was cycled 10,000 times is called Bolt 1. Bolts 2-5 are the bolts cycled 5,000 times, and bolt 11 is the bolt with the old-style ISS.





Bolt Torques

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 1	Lock torque before test	1.713667	1.769145	1.300661	1.272922	1.223608	1.456	0.262729
	Unlock torque before test	1.134226	1.195868	1.035597	1.091076	0.992447	1.089843	0.080064
	Lock torque after 5000 cycles	0.906148	0.859916	0.810601	0.776698	0.758205	0.822314	0.060766
	Unlock torque after 5000 cycles	0.899983	0.912312	1.01094	0.992447	0.977037	0.958544	0.049506
	Lock torque after 10000 cycles	0.893819	0.785944	0.727384	0.730466	0.715055	0.770534	0.074132
	Unlock torque after 10000 cycles	0.530127	0.551702	0.551702	0.545538	0.539374	0.543689	0.009143

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 2	Lock torque before test	1.605792	1.380796	1.519492	1.171211	1.057172	1.346893	0.230636
	Unlock torque before test	1.066419	1.109569	0.973955	1.060254	1.124979	1.067035	0.0589
	Lock torque after 5000 cycles	0.912312	0.776698	0.696562	0.739712	0.67807	0.760671	0.093636
	Unlock torque after 5000 cycles	1.288332	1.032515	1.05409	1.131149	1.103404	1.121897	0.10089

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 3	Lock torque before test	1.223608	1.057472	1.041762	1.004776	0.986283	1.06272	0.09428
	Unlock torque before test	1.081829	0.99553	1.063337	0.998612	1.032515	1.034364	0.038348
	Lock torque after 5000 cycles	0.65083	0.674988	0.641084	0.653413	0.804437	0.68485	0.067996
	Unlock torque after 5000 cycles	1.161965	1.16354	1.020187	1.100322	0.918476	1.076898	0.108939

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 4	Lock torque before test	1.094156	1.032515	1.001694	0.980119	0.983201	1.018337	0.047228
	Unlock torque before test	1.263675	1.337647	1.3284	1.174293	1.282168	1.277237	0.065331
	Lock torque after 5000 cycles	0.745877	0.739712	0.718137	0.684234	0.718137	0.72122	0.024171
	Unlock torque after 5000 cycles	1.235936	1.211279	1.165047	1.112651	1.004776	1.145938	0.091882

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 5	Lock torque before test	1.37155	1.177376	1.208197	1.189704	1.115733	1.212512	0.095437
	Unlock torque before test	1.396207	1.300661	1.359221	1.214361	1.106486	1.275387	0.116743
	Lock torque after 5000 cycles	1.029433	0.86608	0.856833	0.801355	0.829094	0.876559	0.089132
	Unlock torque after 5000 cycles	0.684234	0.711973	0.702727	0.690398	0.665741	0.691015	0.017759

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 6	Lock torque before test	1.37155	1.177376	1.208197	1.189704	1.115733	1.212512	0.095437
	Unlock torque before test	1.396207	1.300661	1.359221	1.214361	1.106486	1.275387	0.116743
	Lock torque after 5000 cycles	1.029433	0.86608	0.856833	0.801355	0.829094	0.876559	0.089132
	Unlock torque after 5000 cycles	0.684234	0.711973	0.702727	0.690398	0.665741	0.691015	0.017759

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 7	Lock torque before test	1.972566	1.870856	1.51641	1.470178	1.260593	1.618121	0.29562
	Unlock torque before test	1.368468	1.365386	1.405453	1.303743	1.309907	1.350591	0.043007

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 8	Lock torque before test	1.821542	1.300661	1.112651	1.075665	1.051008	1.272305	0.322333
	Unlock torque before test	1.09724	1.229772	1.390043	1.297579	1.260593	1.255045	0.106777

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 9	Lock torque before test	1.454768	1.09724	0.986283	1.574971	0.955462	1.213745	0.283107
	Unlock torque before test	0.933887	0.961626	0.899983	0.983201	0.964708	0.948681	0.032428

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 10	Lock torque before test	1.4147	1.078747	0.977037	0.940051	0.893819	1.060871	0.209193
	Unlock torque before test	1.334564	1.303743	1.251347	1.374632	1.288332	1.310524	0.046712

		Measurement #						
		1	2	3	4	5	Average	Std. Dev
Bolt 11	Lock torque before test	0.958544	0.927723	0.847587	0.832176	0.826012	0.958544	0.060594
	Unlock torque before test	1.072583	0.711973	0.684234	0.67807	0.662659	0.761904	0.174589
	Lock torque after 5000 cycles	0.893819	0.785944	0.727384	0.730466	0.715055	0.770534	0.074132
	Unlock torque after 5000 cycles	0.530127	0.551702	0.551702	0.545538	0.539374	0.543689	0.009143

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